NextGen Automation: Changing the Knowledge Base

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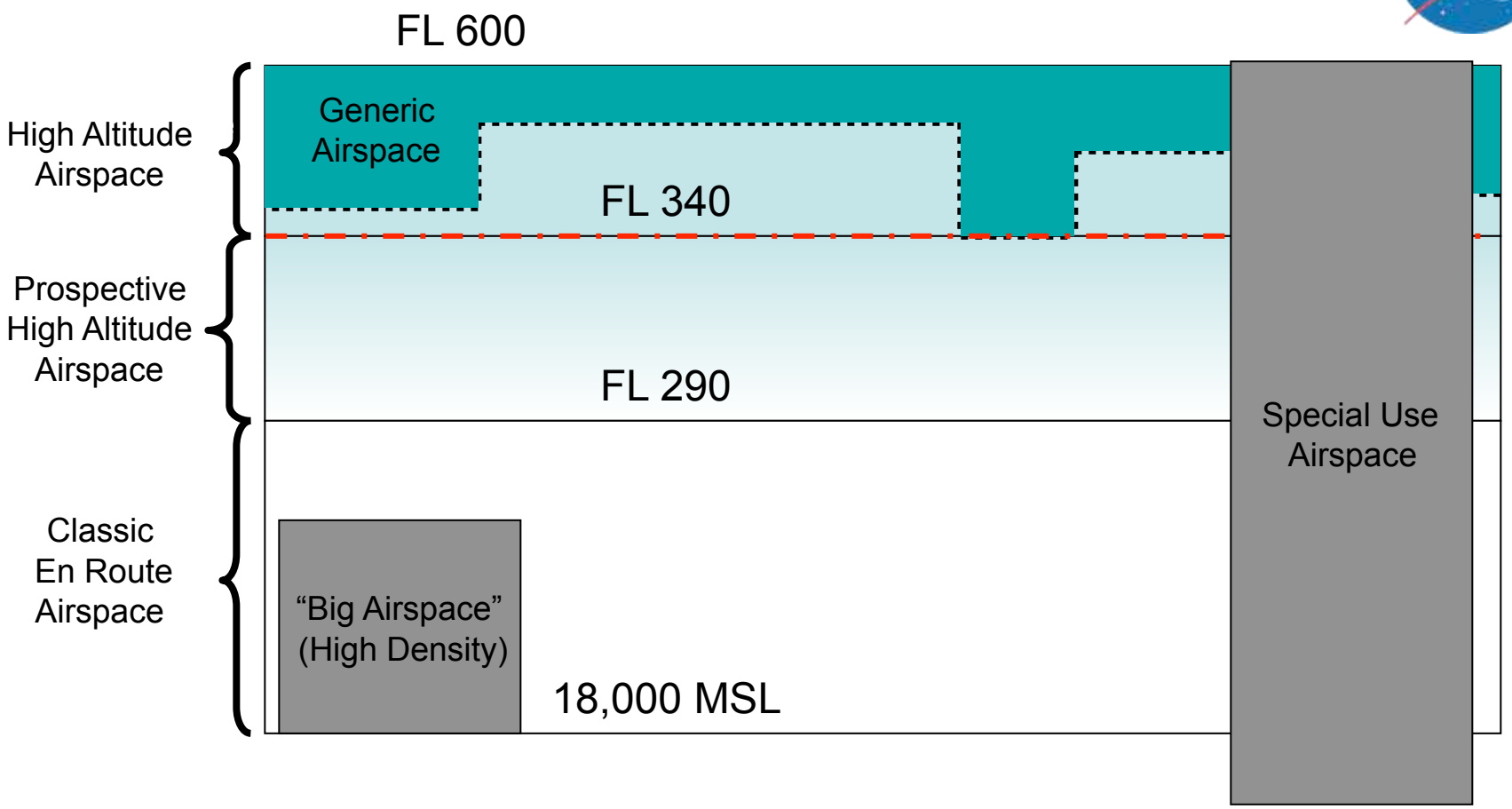
Overview

- Generic Airspace Research
- NextGen Automation
- Human Factors Considerations

Generic Airspace Research

- In the current en route system, controllers are checked out on only five to seven sectors
  - Significant time is required to learn and memorize airspace and procedures
- The Next Generation Air Transportation System (NextGen) may introduce changes in airspace usage and design
  - Controllers could move between more sectors to work traffic, as determined by system needs
  - Dynamic re-sectorization may redefine airspace boundaries based on traffic flow, weather, etc.
  - New operational concepts could require different airspace structure and procedures
- The current paradigm may limit NextGen concepts
- How can we make airspace easier to learn and manage?

FAA High Altitude Concept



- The base of high altitude airspace may vary across the National Airspace System
- All generic sectors are contained within high altitude airspace
- Trajectory Based Operations will be introduced first in high altitude airspace
- Access to high altitude airspace will be restricted to equipped aircraft

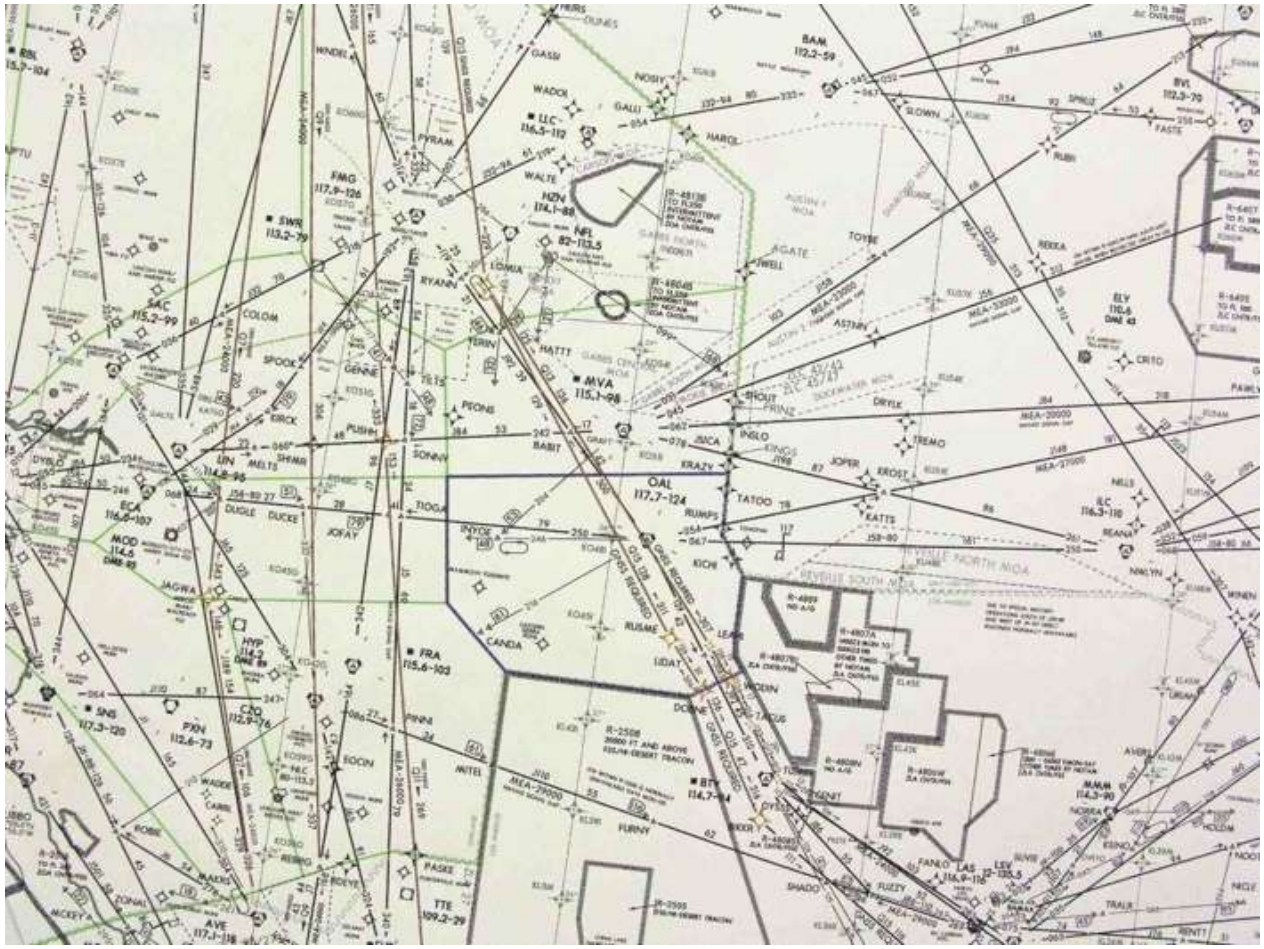
Generic Airspace Strategies

Three approaches for making airspace easier to learn and manage:

1. Identify sector information needed by the controller and display it at the radar position
2. Incorporate automation
   - May reduce or eliminate the need for memorizing sector information
3. Modify sector characteristics or topography
   - Change boundaries, shape, size, navigational references, labeling, etc.

Prior research: Universal High Altitude Airspace study conducted by MITRE.

Oakland Center Airspace



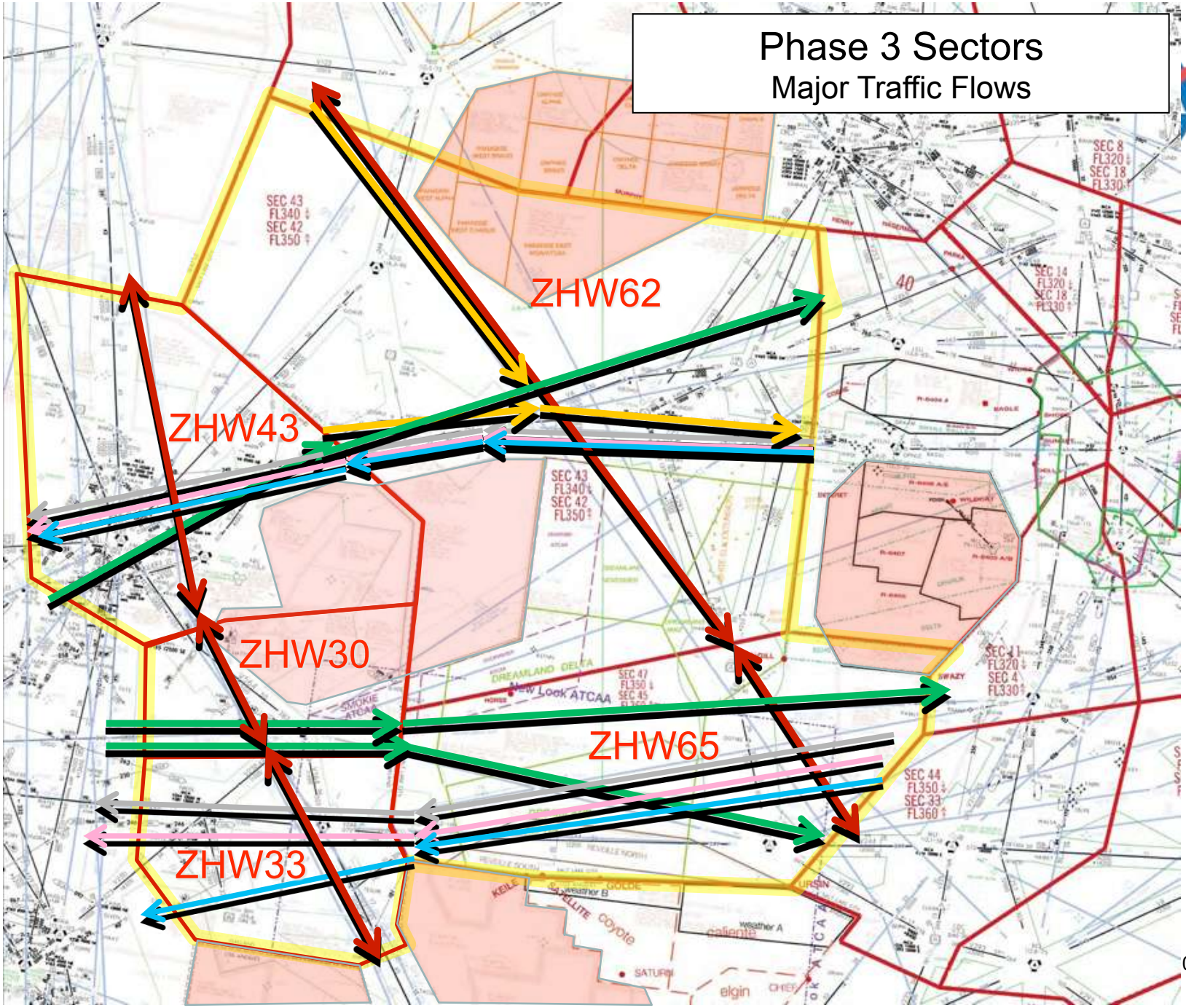
Approach

- Created a “Controller Information Tool” (CIT) to assist controllers to manage generic sectors
- Met with Airspace and Procedures Office at Oakland Center (ZOA) to determine information needed by controllers
  - Sector boundaries
  - Special Use Airspace
  - Altitudes, frequencies, and sector numbers
  - Fixes and navigational aids
  - Typical traffic flows
  - Procedures and Letters of Agreement
- Completed four phases of feasibility research

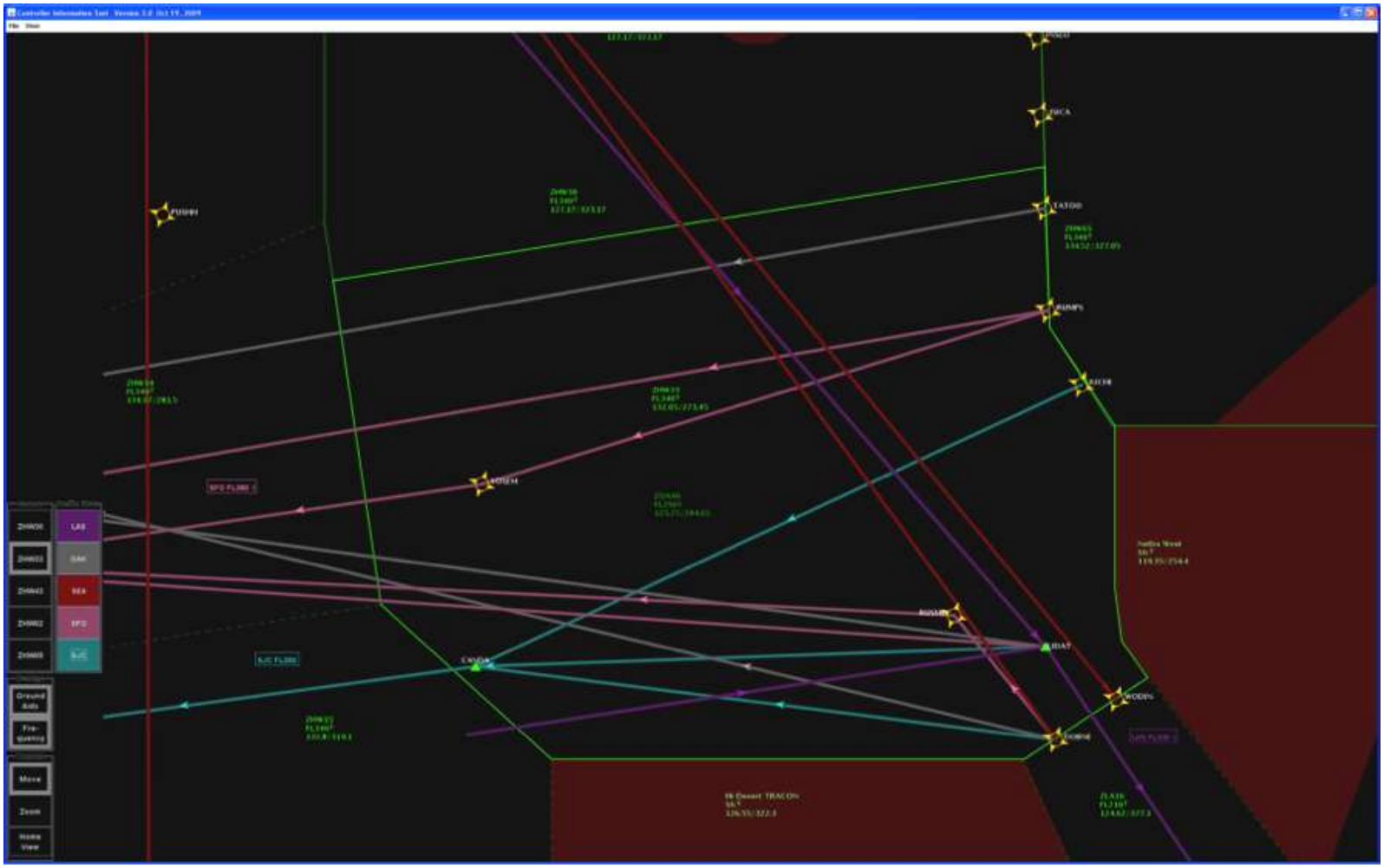
Controller Information Tool

Phase 3 Experiment

- Human-in-the-loop experiment
  - To simulate generic sectors, we asked controllers to work unfamiliar airspace
  - Research goal:
    - Determine whether controllers can manage unfamiliar sectors with an acceptable level of efficiency and safety, as compared to familiar sectors
- Test environment
  - Created a “West High Center” which included ZOA sectors 30, 33 and 43, and Salt Lake City (ZLC) sectors 42 and 45
  - Presented the information needed by the controllers to manage each of the five sectors
  - Datacomm for transfer of communication and for sending route changes and clearances
  - Manual conflict detection and resolution (CD&R) for managing separation
  - Five controllers worked traffic in both familiar and unfamiliar sectors


Phase 3 Sectors
Major Traffic Flows
ZHW62
ZHW43
ZHW30
ZHW65
ZHW33
SEC 43
FL340
SEC 42
FL350
SEC 8
FL320
SEC 18
FL330
SEC 14
FL320
SEC 18
FL330
SEC 43
FL340
SEC 42
FL350
SEC 47
FL350
SEC 45
SEC 41
FL320
SEC 4
FL330
SEC 44
FL350
SEC 33
FL360
DREAMLAND DELTA
New Look ATCAA
SMOKIE ATCAA
SATURN
elgin

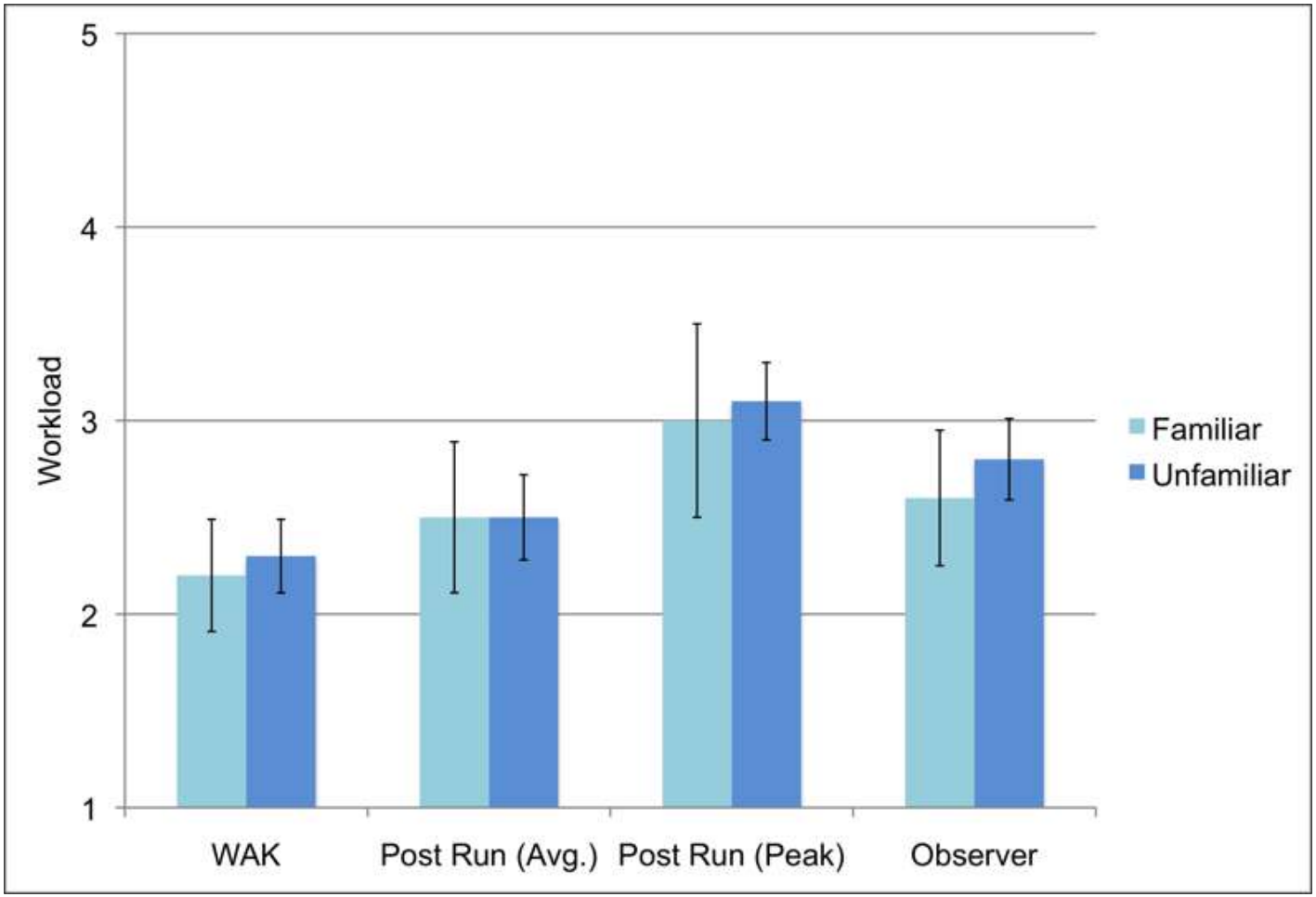
CIT Single Sector View



Results

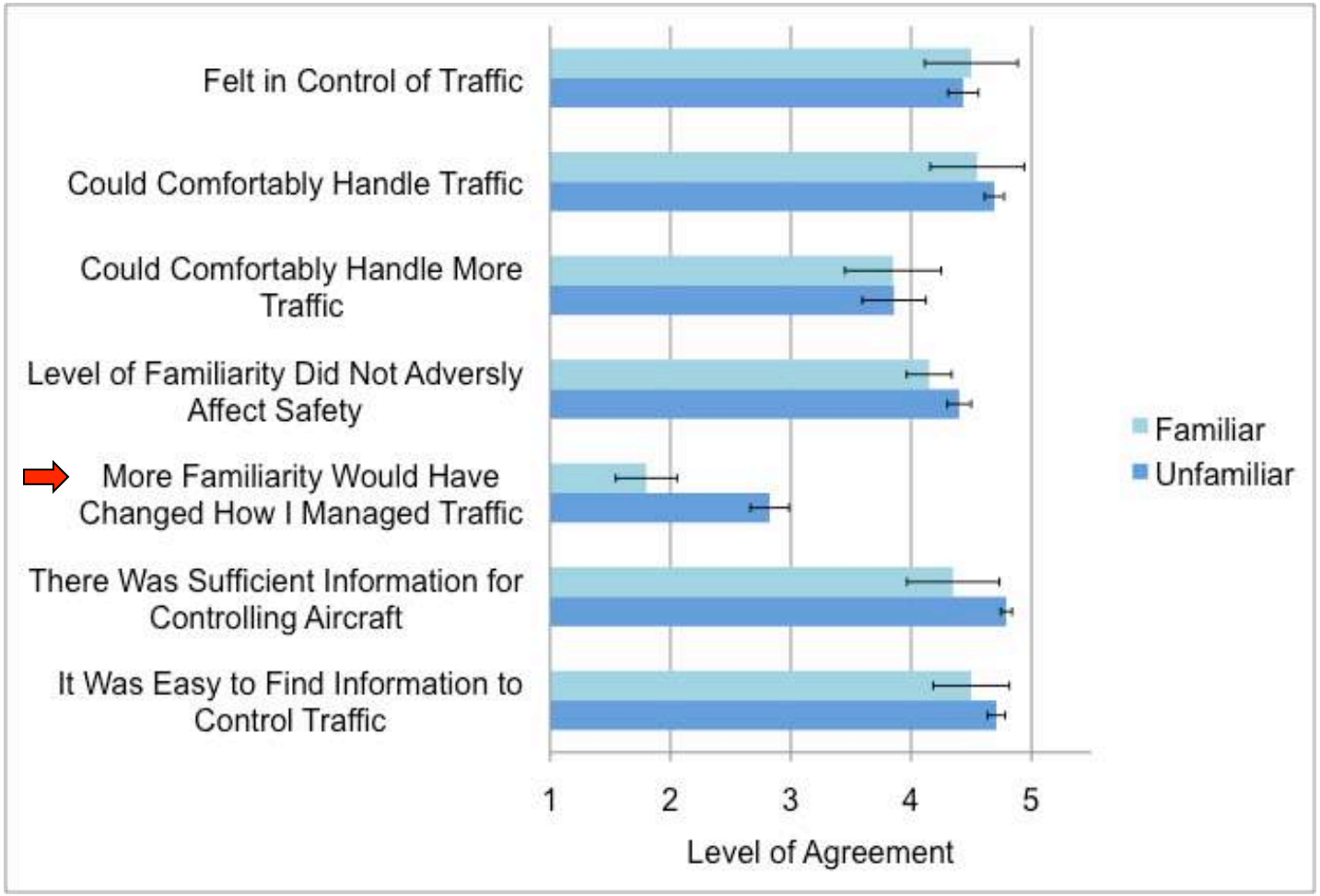
- Generic airspace concept seemed to be feasible (within study conditions)
  - Controllers found it acceptable to manage unfamiliar sectors, with the assistance of important sector data and NextGen tools
  - Observers agreed with this finding
- Data supported generic sector concept
  - Workload measures collected every five minutes and after each run showed small workload differences between familiar and unfamiliar sectors
  - Participants reported feeling in control of traffic and that safety was maintained
  - Comments:
    - Larger variety of sectors to work could improve job satisfaction and reduce complacency
    - Less familiarity might result in more basic control strategies and reduced service to aircraft

Results



Comparable workload ratings for familiar and unfamiliar sectors.

Results



Acceptable ratings for both familiar and unfamiliar sectors.

➡ = statistically significant difference

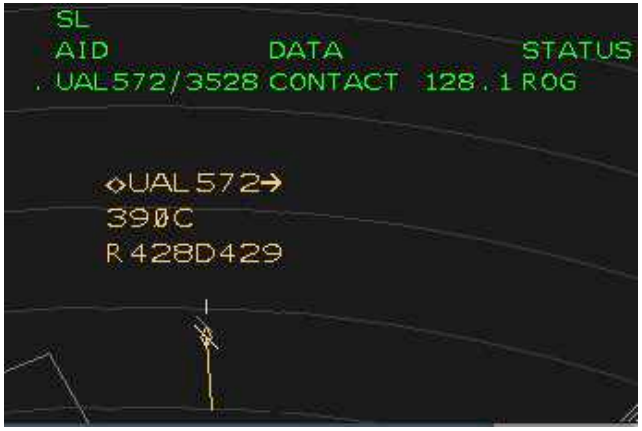
Summary

- Generic sectors may be feasible assuming:
  - High altitude, low to moderate complexity airspace
  - Sector data provided to controller
  - NextGen tools to assist controller and reduce sector information requirements
- Further research has recently been completed on off-nominal conditions (e.g., higher traffic, weather, datacomm failures, etc.)
- We will continue to collaborate with the FAA on how generic airspace will be included in their high altitude concept

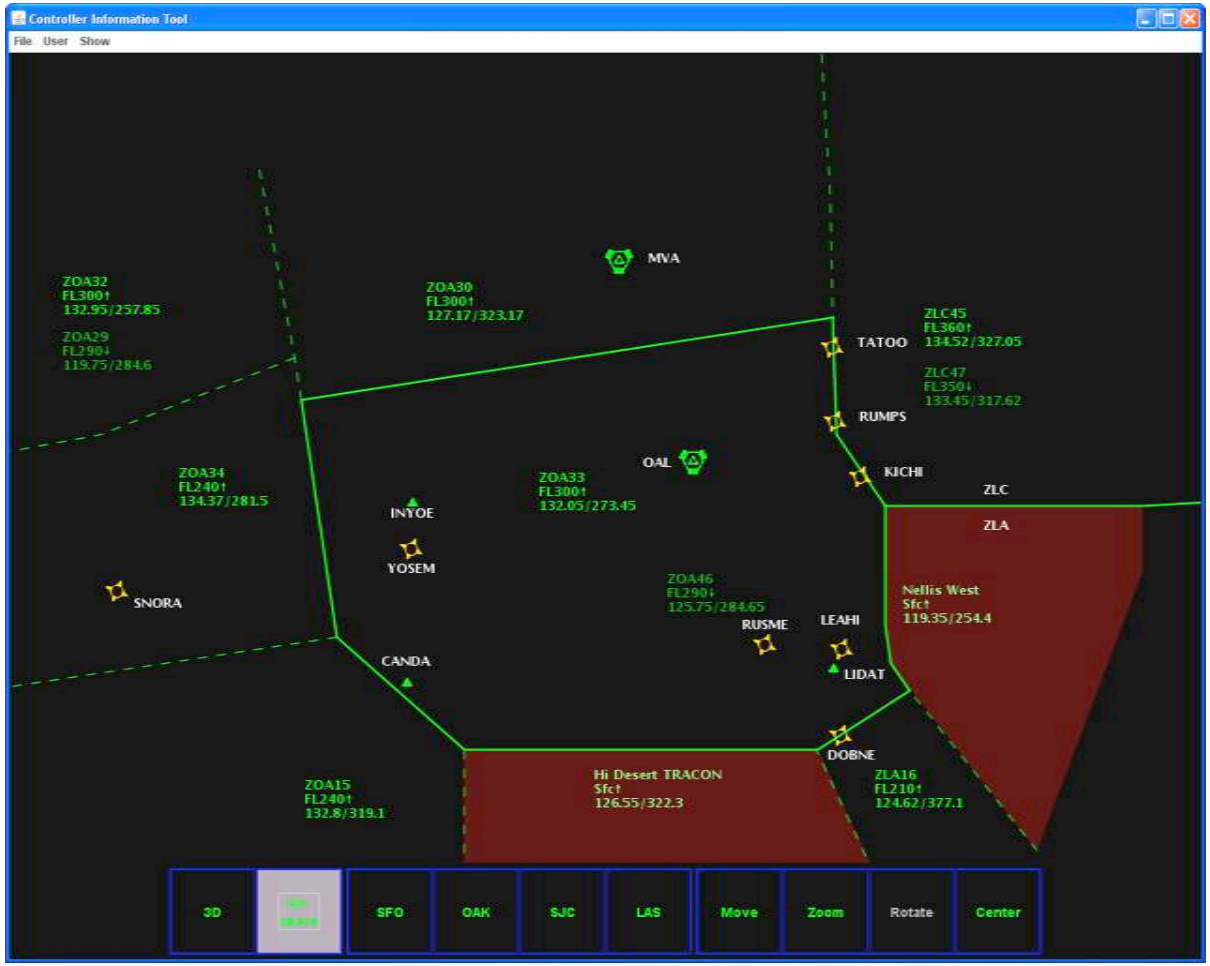
Human Factors Implications

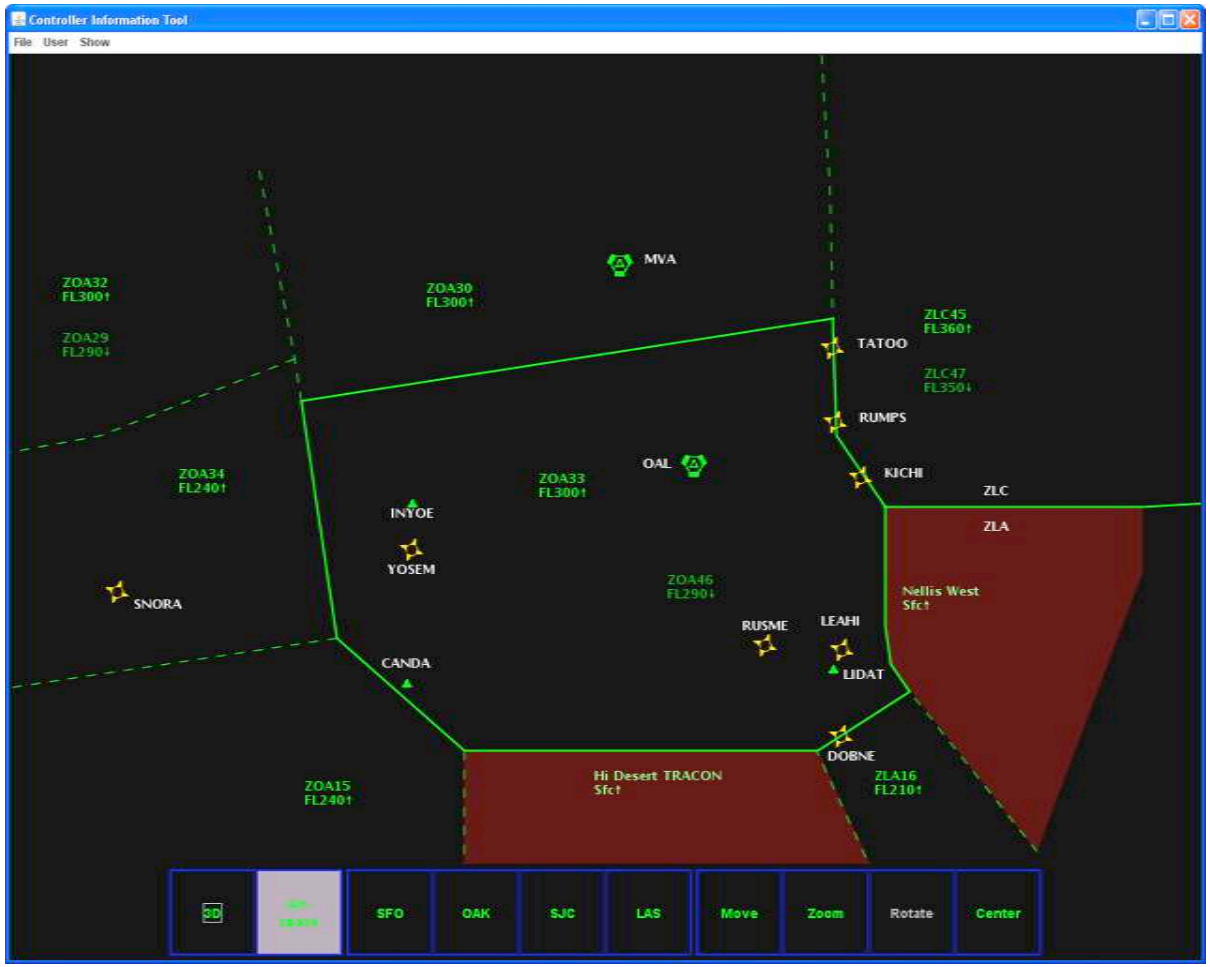
- Cognitive psychology distinguishes between procedural and declarative knowledge (and memory)
  - Procedural: skills
  - Declarative: facts
- NextGen tools (e.g., conflict detection and resolution) may perform tasks currently handled by the controller
- Research shows that there may also be changes in declarative knowledge, or the facts the controller must know
  - Controllers may have less requirement to use sector frequencies, numbers, and navigational references

Datacomm Transfer of Communication

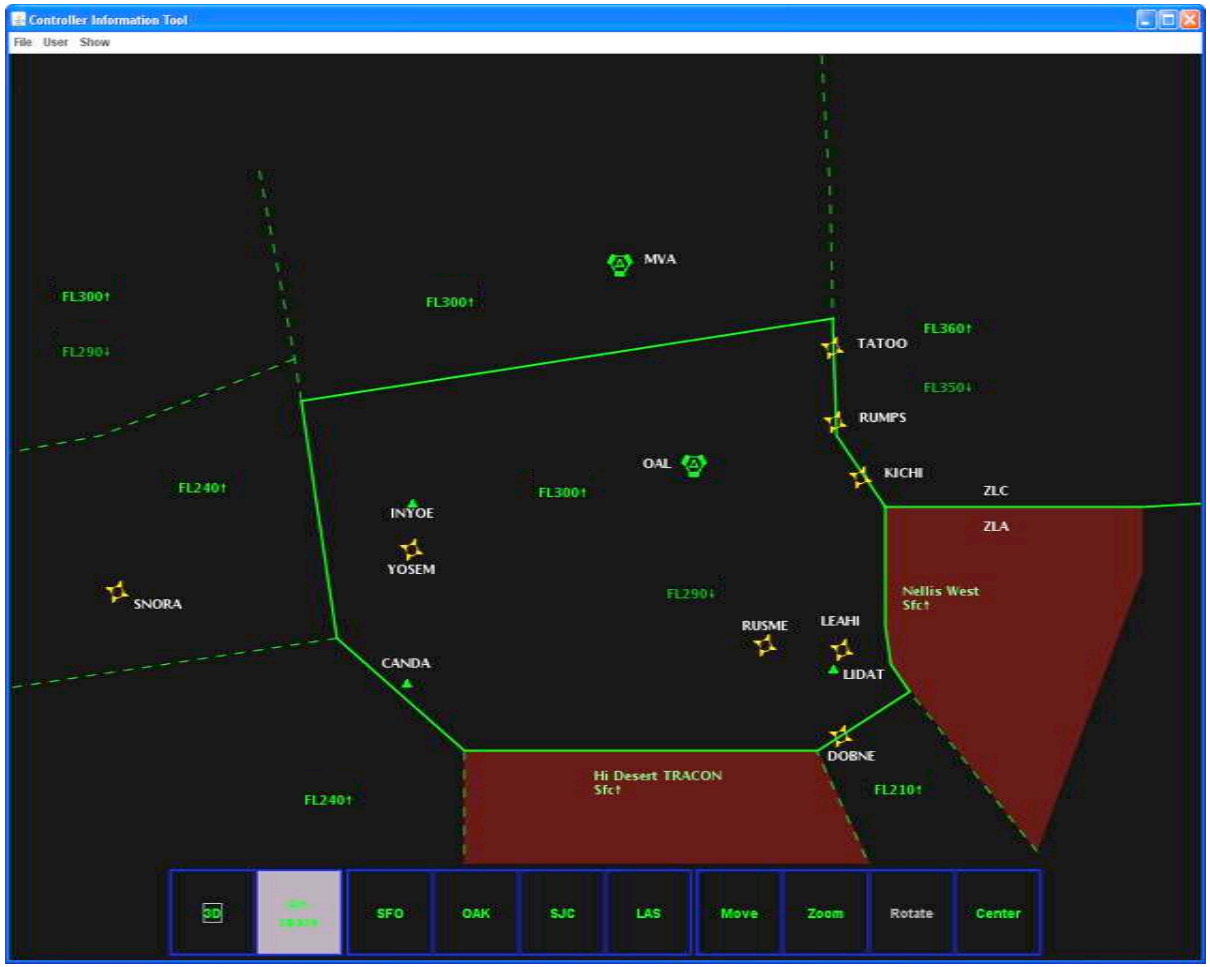


Datacomm is used to transfer aircraft to next sector frequency.
Handoff may also be automated.


Controller Information Tool
File User Show
MVA
ZOA32
FL300↑
132.95/257.85
ZOA29
FL290↓
119.75/284.6
ZOA30
FL300↑
127.17/323.17
ZLC45
FL360↑
134.52/327.05
TATOO
ZLC47
FL350↓
133.45/317.62
RUMPS
OAL
KICHI
ZLC
ZOA34
FL240↑
134.37/281.5
ZOA33
FL300↑
132.05/273.45
INYOE
YOSEM
ZLA
SNORA
ZOA46
FL290↓
125.75/284.65
Nellis West
Sfc↑
119.35/254.4
RIUSME
LEAHI
CANDA
LIDAT
DOBNE
Hi Desert TRACON
Sfc↑
126.55/322.3
ZLA16
FL210↑
124.62/377.1
ZOA15
FL240↑
132.8/319.1
3D
SFO
OAK
SJC
LAS
Move
Zoom
Rotate
Center



Controller no longer needs to remember adjacent sector frequencies.

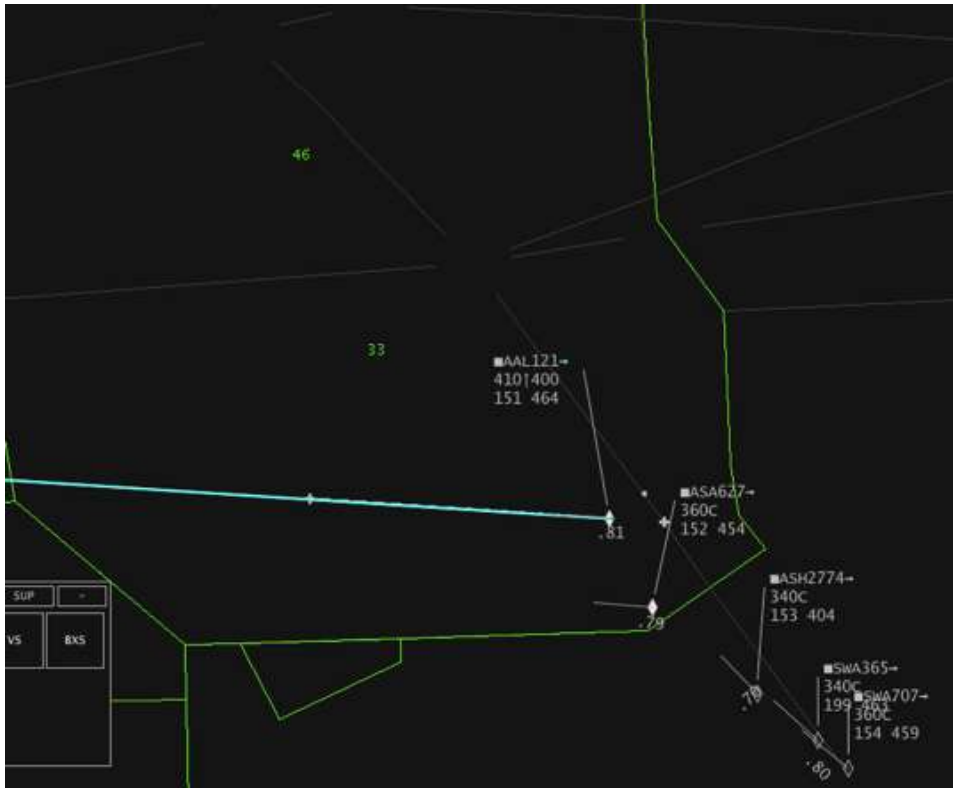


Controller no longer needs to remember adjacent sector numbers.

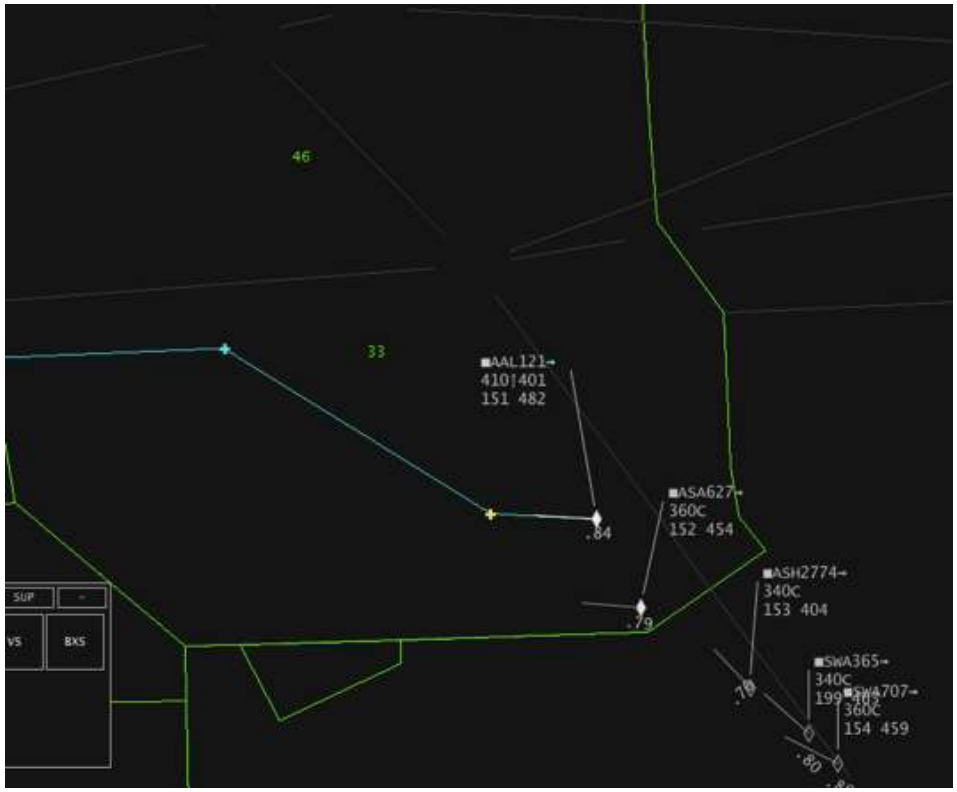
Datacomm Route Modification

Graphics-based tools visualize, modify, and communicate flight paths, using datacomm.

Datacomm Route Modification



Datacomm Route Modification



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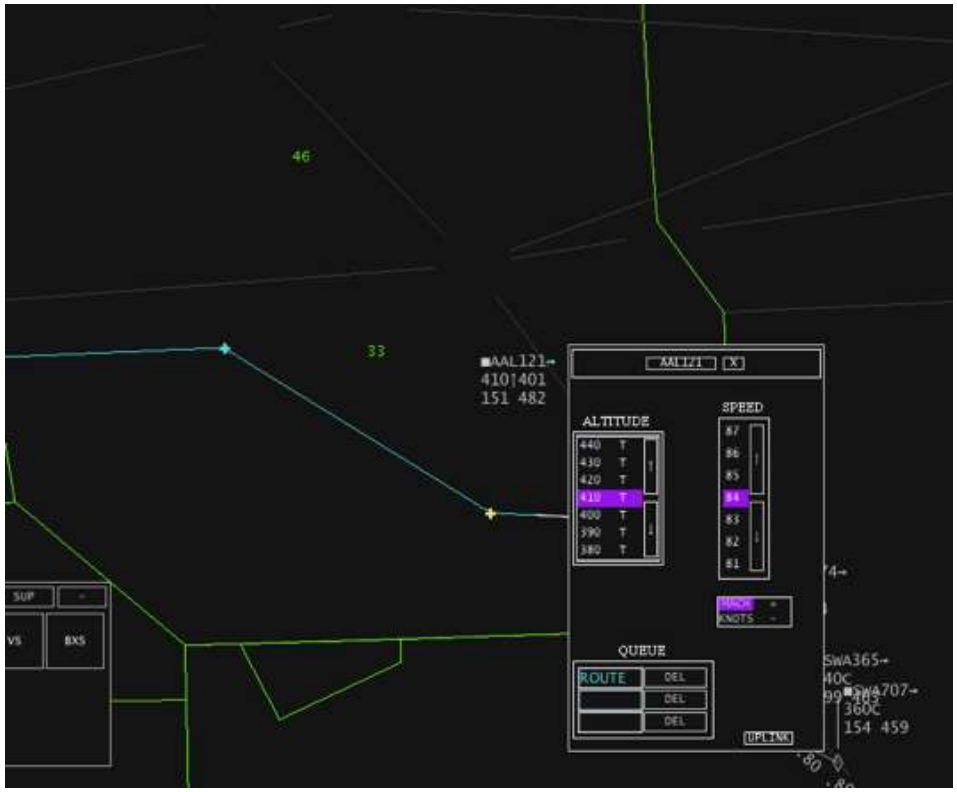
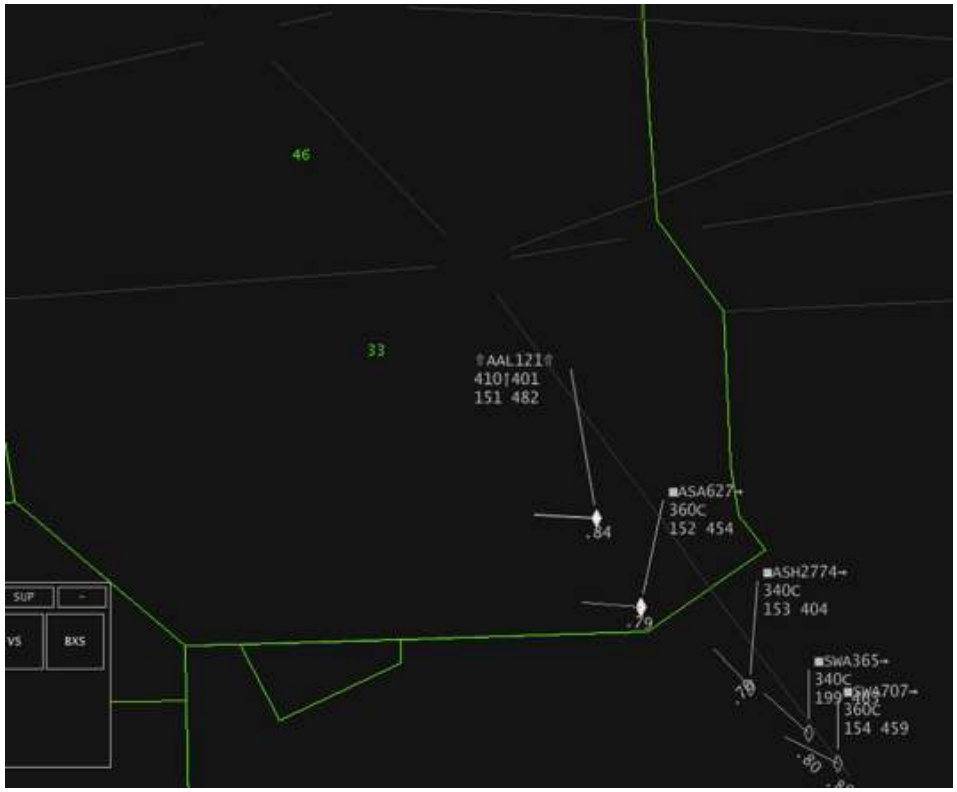


Datacomm Route Modification



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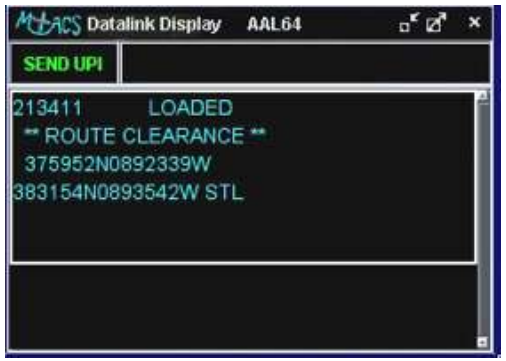
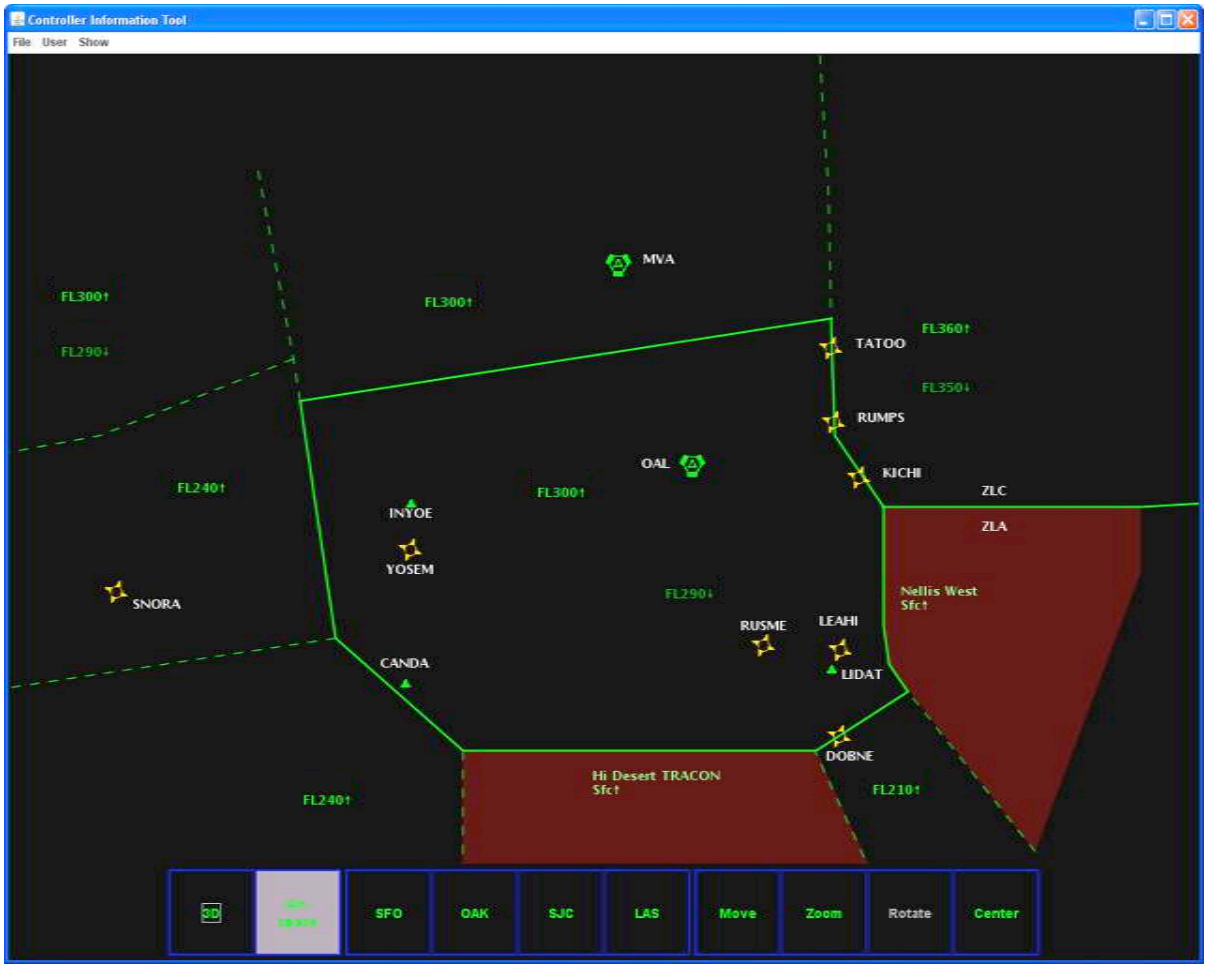


Route modification is received on flight deck and loaded into the Flight Management System.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OAL
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FL240↑
INYOE
YOSEM
SNORA
FL290↓
Nellis West
Sfc↑
RIUSME
LEAHI
LIDAT
CANDA
DOBNE
Hi Desert TRACON
Sfc↑
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3D
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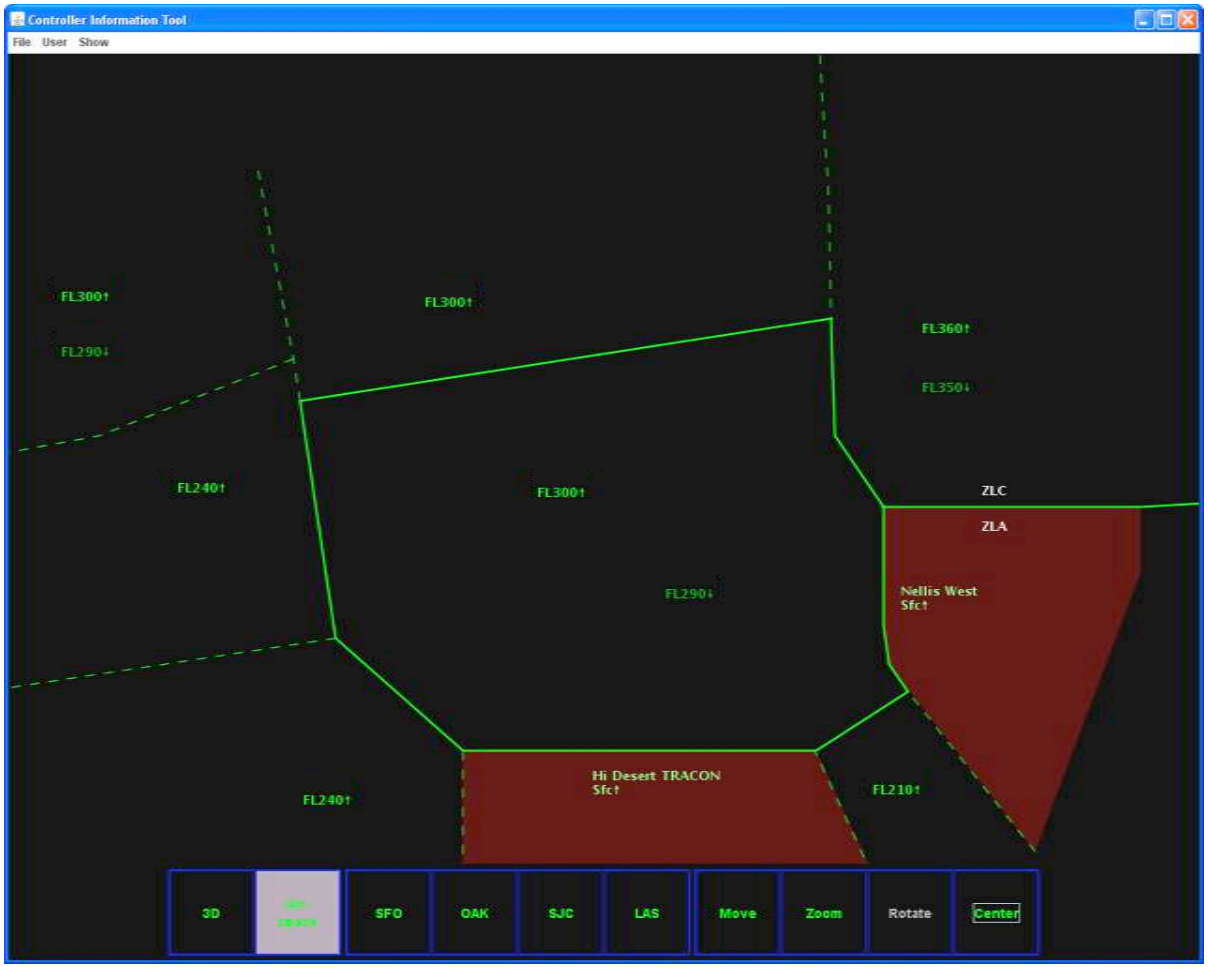
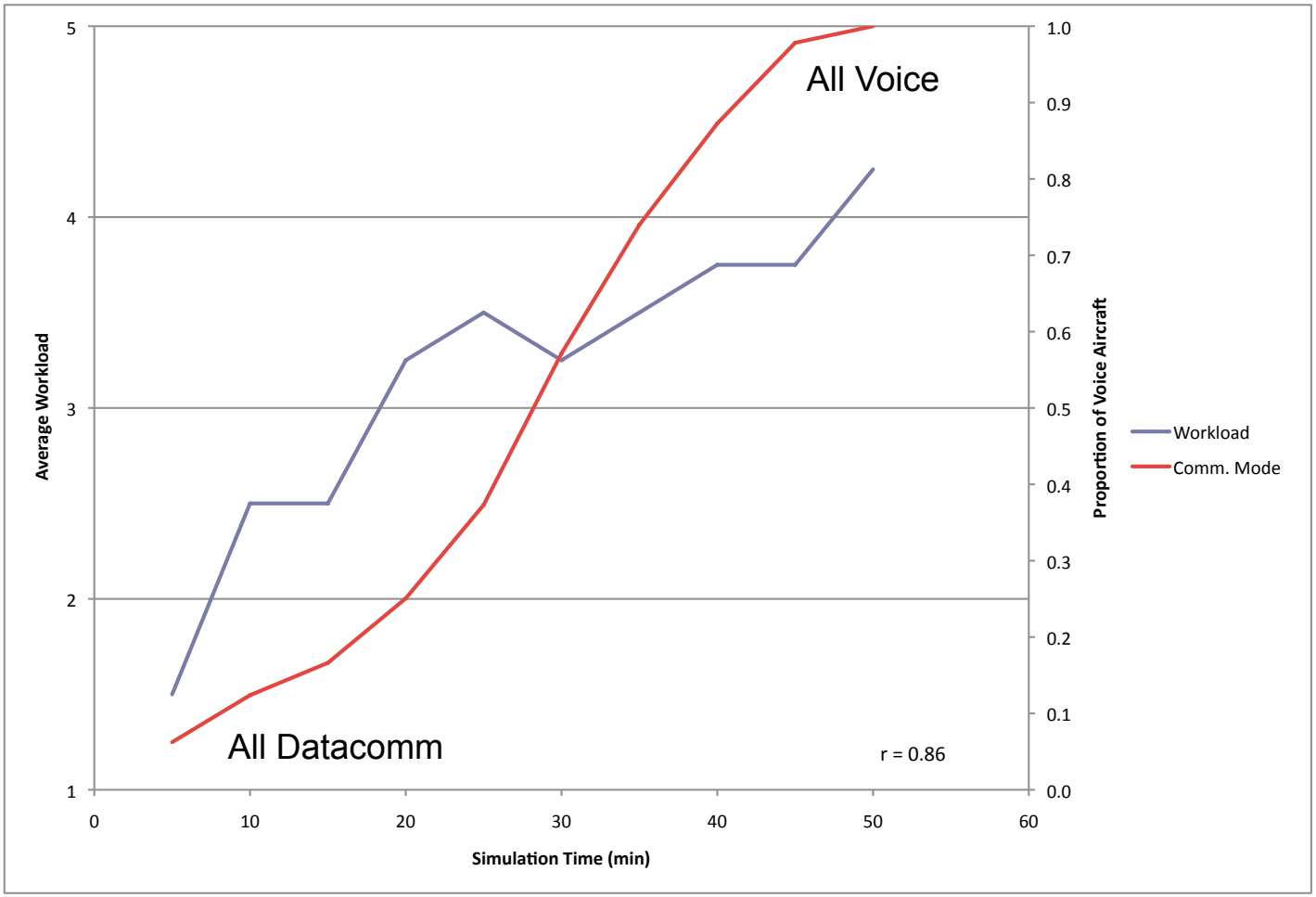
Center



Fewer navigational references need to be memorized.

Workload: Datacomm vs. Voice



Research shows that datacomm may reduce controller workload.

NextGen Concepts Change Factual Knowledge Base

- Outcomes
  - With datacomm, controllers may have less requirement to use sector data
  - NextGen automation should reduce the amount of information that the controller needs to learn, recall, and actively retain in memory
- Benefits
  - Decrease training time
  - Allow controllers to adapt to changes in airspace or work more sectors
  - Free up cognitive capacity for other tasks
- Concerns
  - Less prepared for off-nominal situations
    - If automation fails, must look up information
    - Reduced flexibility in emergencies

Conclusions

- NextGen automation will affect the controller's and pilot's interaction with air traffic management systems
- NextGen may:
  - Change the skills controllers need
  - Create reliance on automation
  - Alter what controllers must know to manage traffic
- As NextGen concepts are specified, human factors analyses and human-in-the-loop testing are needed to ensure systems are viable under all conditions
- New systems must:
  - Retain a supportable role for the human
  - Include failure states that the human can manage